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Evaluation of the effect of COVID-19 disease on ventricular density using computer tomography

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Abstract

Aim: Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) is a novel coronavirus identified at the end of 2019. Radiological examinations, especially thorax Computed Tomography (CT), play an important role in the fight against this infectious disease. In this study, we aimed to analyze the effect of COVID-19 disease on the cardiac ventricles by measuring density on CT.

Materials and Methods: Patients who underwent thorax CT with a pre-diagnosis of COVID-19 and whose Polymerase Chain Reaction (PCR) test was positive, and patients who underwent CT for any reason were included in the study. Among 270 patients included in the study, 147 were men, 123 were women, and the mean age was 45.5 (29.2-62) years. The patients with a positive PCR test were divided into three groups. The control group and the three groups were compared with each other in terms of age, gender, CTR, right and left ventricular density.

Results: In both studies, a significant difference was found between the groups in terms of age ($p<0.005$). There was no significant difference between Group 1 and Group 3 in terms of age, right and left ventricular density, and CTR ($p>0.005$).

Discussion: In patients with COVID-19, cardiovascular comorbidities are common. Therefore, early diagnosis will boost the effectiveness of treatment. Considering the severity of the disease and the primary focus on managing infection and respiratory failure, not all patients have complete cardiac data and imaging results are not available. Ventricular density and CTR measurements on CT did not yield significant results in COVID-19 patients. However, we think that more patients and appropriate imaging will yield important results, as previous studies have shown the impact of COVID-19 disease on the cardiovascular system.

Keywords

COVID19; Tomography; Cardiomyopathies; Cardiac ventricles

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Introduction

Coronavirus disease (COVID-19) has emerged as a global pandemic. A significant aspect of reducing the spread of this virus is its early and accurate diagnosis and effective quarantine for those infected [1]. In the fight against this infectious disease, radiological examinations, especially thin-slice thoracic computed tomography (CT), play an important role. Although the results of the polymerase chain reaction (PCR) test are negative, CT can identify individuals people suspected of having COVID-19 [2]. Radiological examinations are greatly important in the early diagnosis and treatment of COVID-19. Since a chest radiograph has a lower resolution and may be normal in the early stage of infection, it is not recommended as a first-line imaging technique for COVID-19 [3]. Physicians have recently recorded an increase in stress cardiomyopathy during the COVID-19 outbreak worldwide, with an unknown mechanism behind it [4].

In our study, we aimed to show the effect of COVID-19 disease on the cardiac ventricles by measuring ventricular density on CT.

Material and Methods

Permissions for this study were obtained from the ...University Non-Invasive Research Ethics Committee and the Ministry of Health. Since the study was retrospective and no risk was noted for patients, informed consent was waived.

Without intravenous contrast agent administration, all images were taken on a single scanner (Philips Healthcare, Ingenuity Elite Netherland) with the patient in supine position and inspiration. The CT protocol was as follows: 120 kV, auto tube current 100–200 mA, 128 mm detector, and slice thickness 2–5 mm. Image analysis was performed using an institutional digital database system.

Medical records and images of patients who had thoracic CT between April and July 2020 with a preliminary diagnosis of COVID-19 and who had a positive PCR test, as well as records and images of patients who had thoracic CT between April and July 2019 as a control group for any reason were scanned retrospectively. The study was conducted in a single center in ... State Hospital.

In our first study, patients were divided into two groups: pre- and post-COVID-19 periods. The first group was divided into patients with a negative PCR test and no CT pathology and the second group into patients with a positive PCR test and who ignored CT involvement.

Among 270 patients included in the study, 147 (54.4%) were male and 123 (45.6%) were male. The average age of all patients was 45.5 (29.2-62) years.

In our second study, the same patients in Group 2 were divided into two different sub-groups. Patients with a negative PCR test and normal CT were assigned to Group 1; patients with a positive PCR test and normal CT were assigned to Group 3; patients with a positive PCR and involvement on CT were assigned to Group 4.

In the cardiothoracic ratio (CTR), the right and left ventricular densities in all patients were measured by a single expert radiologist with 8 years of experience with the hospital imaging system on the axial slice of unenhanced thoracic CTs.

Statistics

All statistical analyses were performed using SPSS version 20.0 (SPSS Inc, Chicago, IL). Continuous variables were expressed as mean ± standard deviation or median values and ranges, whereas categorical variables were expressed as absolute numbers. The Kruskal–Wallis one-way analysis of variance tests was used for intergroup comparisons; while the Bonferroni test was used for post hoc analysis (p-value < 0.05 was considered statistically significant). Also, the Student's t-test and the Mann–Whitney U test were used for intergroup comparisons (p-value < 0.05 was considered statistically significant).

Results

A total of 270 patients, 69 before COVID-19 between April and July 2019 and 201 during the period of COVID-19 between April and July 2020 were included in the study. They were first divided into two groups based on their PCR and CT results. Group 1 included patients with a negative PCR test and normal CT findings (Figure 1), while Group 2 included patients with a positive PCR test and CT (whose CT findings were ignored). Both groups were compared with each other in terms of age, gender, CTR, and right and left ventricular densities.

There was a significant difference in the mean age between the two groups (pre-COVID-19 period, 41.8 ± 12.7 [29.1–54.5] years, and COVID-19 period, 46.9 ± 17.4 [29.5–64.3]) (p = 0.01) (Table 1), which may be due to the extreme course of COVID-19 disease in the elderly, requiring further imaging and hospitalization. The total mean age was 45.6 ± 16.4 [29.2–62] years. One hundred forty-seven (54.4%) of the patients included in the study were male and 123 (45.6%) female. In Group 1, 27 (39.1%) of the 69 patients were female and 42 (60.8%) were male. In Group 2, 96 (47.7%) of the 201 patients were female and 105 (52.2%) were male. There was no significant difference between the groups in terms of gender (p = 0.214), right ventricular and left ventricular densities, and CTR (Table 1).

Group 2 was later divided into two additional groups based on the presence of CT involvement: Groups 3 and 4. Group 3 included patients with a positive PCR test and normal CT findings, while Group 4 included patients with a positive PCR test and CT findings (Figure 2). Groups 1, 3, and 4 were compared in terms of age, gender, CTR, and right and left ventricular densities.

In Group 3, 32 (45.7%) of the 70 patients were female and 38 (54.2%) were male. In Group 4, 64 (48.8%) of the 131 patients were female and 67 (51.1%) were male. There was no significant difference in terms of gender between the groups (p = 0.779). The mean age in total was 45.6 ± 16.4 [29.2–62] years. A significant difference between the groups in terms of age was also observed (p < 0.001). In post hoc analysis, there was a significant difference between Groups 1 and 4 (p < 0.001) and Groups 3 and 4 in terms of age (p = 0.001).

We suppose that this difference is due to the severe course of COVID-19 disease in the elderly, requiring additional imaging and hospitalization, whereas there was no significant difference between Groups 1 and 3 (p = 0.970). In terms of right ventricular and left ventricular densities and CTR (Table 2), no significant difference was found between the groups.

Table 1. Comparison of the patient groups before and after COVID-19 by PCR

	Total (n = 270)	Group 1 (n=69)	Group 2 (n=201)	P value
Gender (M/F)	147/123	42/27	105/96	0.214
Age (median (min-max))	45.5 (29.2-62)	41.8 (29.1-54.5)	46.9 (29.5-64.3)	0.001*
RVD (median (min-max))	43.5 (37.1-49.9)	43.4 (37.8-49)	43.6 (37-49.9)	0.876
LVD (median (min-max))	46 (21-66)	46 (34-65)	46 (21-66)	0.604
CTR (median (min-max))	0.5 (0.3-0.6)	0.5 (0.3-0.5)	0.5 (0.3-0.6)	0.290

* p <0.005, RVD; Right ventricular density, LVD; Left ventricular density, CTR; Cardiothoracic Ratio, PCR; Polymerase Chain Reaction

Table 2. Comparison of the patient groups by PCR and CT involvement before and after COVID-19

	Total (n = 270)	Group 1 (n=69)	Group 3 (n=70)	Group 4 (n = 131)	P value
Gender (M/F)	147/123	42/27	38/32	67/64	0.422
Age (median (min-max))	45.6 (37.1-49.9)	41.8 (29.1-54.5)	40.7 (23.6-57.8)	50.2 (33.6-66.8)	0.001*
RVD (median (min-max))	43.5 (39.1-49.9)	43.4 (37.8-49)	44.1 (38-1-60.1)	43.3 (36.4-50.2)	0.729
LVD (median (min-max))	46 (21-66)	46 (34-65)	47 (31-66)	46 (21-65)	0.386
CTR (median (min-max))	0.5 (0.3-0.6)	0.5 (0.3-0.5)	0.4 (0.3-0.6)	0.5 (0.3-0.6)	0.124

* p <0.005, RVD; Right ventricular density, LVD; Left ventricular density, CTR; Cardiothoracic Ratio, PCR; Polymerase Chain Reaction

Discussion

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) is a novel coronavirus first identified in Wuhan, China, at the end of 2019. It has caused more than 1,700,000 confirmed COVID-19 cases and nearly 110,000 deaths worldwide. It is responsible for respiratory syndrome, ranging from mild flu-like symptoms to severe respiratory failure (due to acute respiratory distress syndrome), shock, multi-organ failure, and death [5].

In patients with COVID-19, cardiovascular comorbidities are common, and these patients are at a greater risk of morbidity and mortality [6]. Therefore, early diagnosis will boost the effectiveness of treatment.

Myocardial inflammation accompanied by regional scarring and pericardial enhancement was the most common pathology found in 60 patients who had recently recovered from COVID-19 [7].

Evidence from animal models and human studies suggests that viral infections can cause severe damage to cardiomyocytes through direct virus-mediated and secondary immune reactions, eventually leading to chronic myocarditis and dilated cardiomyopathy [8].

Autopsy data on infection provided by SARS-CoV in 2003 and MERS-CoV in 2012 will help better understand the function of the cardiovascular system. ACE2 is the putative receptor for SARS viruses, found mainly in epithelial cells of the upper respiratory region, pulmonary endothelium, and pulmonary alveolar pneumocytes and in other cell types in different organs as well, including the heart and kidneys. In the literature, a case of cardiac tamponade in a 47-year-old man infected with SARS-CoV-2 was identified as a complication of myocarditis and pericarditis [9]. The rates of heart damage and mortality are significantly associated with COVID-19 patients [10].

Myocardial damage associated with COVID-19 may represent myocarditis in some patients with or without pre-existing cardiovascular disease. Acute myocarditis following a COVID-19-associated respiratory tract infection in a 53-year-old Italian woman who had no prior heart disease has also been documented by Inciardi et al. and supports this hypothesis. Considering the severity of the disease and the primary focus on managing infection and respiratory failure, not all patients have complete cardiac data, including electrocardiography, and their echocardiography, coronary angiography, and magnetic resonance imaging results are not available [11].

Conclusion

The above studies have shown the effect of COVID-19 disease on the cardiovascular system. We aimed to display the myocardial damage by measuring density on CT. We believe that due to myocardial inflammation, COVID-19 infection may decrease the ventricular density on unenhanced CT in relation to inflammation and increase ventricular density during the scar formation period. The fact that our study's results was not significant may be due to a lack of understanding of other comorbidities in patients in the control and PCR-positive groups in detail, the age mismatch between the groups, the unenhanced tomography images, and the small number of our patients. We hope that if the contrast-enhanced images are taken with appropriate point and the patients' history is questioned in depth and the number of patients is increased, significant outcomes can be achieved in the future.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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